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CHARACTERISTICS OF PRODUCTION OF MAGNESIUM CAST IRON IN THE USSR

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[Figures, tables, and bibliography are appended. Numbers in parentheses refer to the author's bibliography appended.]

Until recently it was considered that one of the main conditions for the production of quality magnesium cast iron was as full a contact as possible between the magnesium vapors and the cast iron.

Experiments in which magnesium-treated cast iron was diluted with ordinary liquid cast iron were conducted under laboratory conditions. The task was to determine the effect of such an admixture of cast iron on the elimination of cementite formations on the ingots and on the changes of the spheroidal forms of the graphite as well as to ascertain the possibility of substituting an admixture of liquid cast iron for the admixture of ferrosilicon. The cast iron was smelted in a 100-kg induction furnace, treated with an admixture of magnesium, and poured into specimen molds while the remainder was diluted with fresh liquid cast iron.

The chemical composition, the treatment of the individual cast iron pigs, and the pouring of the specimen molds are shown in Tables 1 and 2. The results thus obtained show that admixtures of fresh cast iron do not replace the subsequent admixture of ferrosilicon; 30- to 70-mm-diameter specimens cast from cast iron diluted to an even 50% had cementite inclusions throughout their breadth. The subsequent admixture of ferrosilicon both to the diluted and the undiluted cast iron resulted in increased graphitization and the break down of all the cementite into pearlite-ferrite. The effect of the admixture of fresh cast iron on the preservation of spheroidal graphite is in direct relation to the amount of magnesium initially introduced into the cast iron, to the amount of fresh cast iron added, and to the cross section of the specimens. The characteristics of the structures of the resulting specimens are shown in Figures 1 and 2.

Besides the practical significance, the results obtained supplement the experimental data in regard to the graphitization of cast iron. Apart from the verification of the intensive carbide-forming action of magnesium and the graphitizing action of silicon, it is of consequence that the mixture of the initial liquid cast iron and cast iron treated with magnesium also crystallizes with the separation of spheroidal graphite. This phenomenon confirms the presence of centers of graphitization in magnesium-treated liquid cast iron, which determine the spheroidal form of graphite in the cast structure.

The amount and size of the spheroidal graphite in specimens cast from a mixture of cast iron and not diluted with magnesium are somewhat different. In the mixed cast iron there are 10 to 15% more spheroids and their size is not uniform. Apparently, the carbon of admixed cast iron separates out from the undeveloped centers of graphitization, as a consequence of which there is an increase in the quantity of spheroids, as well as the growth of already existing spheroids, and, as a result, their size is increased somewhat.

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The variation of the carbon content in the cast iron after the admixture of magnesium is of particular interest: in all cases, when free cementite was absent from the structure of the magnesium cast iron, there was a decrease noted in the carbon content by comparison with that of the initial grey cast iron (in the range of 0.15 to 0.8%). There is inconsistent data in regard to this question. Thus P. I. Stepin (1) notes that the carbon concentration in magnesium cast iron remains entirely the same throughout the length of the casting and that migration of globular graphite in liquid cast iron does not occur. However, in studying the effect of silicon admixtures on magnesium treated cast iron, Stepin notes the sharp decrease in its carbon content and notes that the separation of free carbon in liquid cast iron, especially with large admixtures of ferrosilicon, is so great that it is accompanied by an appreciable total decrease in the residual carbon in the smelt, in conjunction with its loss due to coagulation and its being drawn off with the graphite in the slag.

To verify the behavior of carbon, specimens of magnesium cast iron without carbon admixtures and with a subsequent admixture of 75% ferrosilicon were sand- and chill-cast. The former had a ledeburite structure while the latter had a pearlitic-ferritic structure with complete graphite spheroidization.

The refined specimens were tempered to a pearlitic-ferritic structure, while specimens with a pearlitic-ferritic structure were subjected to a secondary smelting.

The results of the chemical analysis and the characteristics of the specimens are listed in Table 3.

The analysis of the specimens of magnesium cast iron, chill cast after the admixture of ferrosilicon, indicates that the carbon content of the cast iron remains practically unchanged both before and after its treatment with magnesium. A carbon content, similar to that of the initial cast iron, was also obtained in magnesium cast iron specimens having a pearlitic-ferritic structure after resmelting to a lamellar graphite structure. The analysis of this same cast iron prior to resmelting showed a reduced carbon content. To obtain free spheroidal graphite for roentgenographic analysis, liquid magnesium cast iron was mixed with 23% of liquid aluminum. If ordinary grey iron is mixed with this amount of aluminum and intensive separation of graphite refining foam results, while the casting becomes porous with a graphitic-ferritic structure (2), then in mixing magnesium cast iron with aluminum these effects were not observed.

Initial cast iron with a high carbon (4.05%) and silicon (2.33%) content was smelted in an induction furnace and poured into a ladle with liquid aluminum. A large separation of slag and graphite refining foam resulted, the carbon content in the poured specimens decreased to 1.88%, instead of 3.118% according to calculation, and an intensive growth of cast iron in the mold was observed. Cast iron in specimens with a diameter of 30 and 110 mm had a coarse crystalline cross-sectional fracture with dark grey spots and in places there were inclusions of free graphite. The hardness of the cast iron was $H_B = 143\text{-}156$.

The same cast iron, preliminarily treated with 0.5% magnesium and 0.3% ferrosilicon, after being mixed with aluminum, had an insignificant amount of slag, the graphite refining foam was absent, and the growth phenomenon of the metal in the mold was not observed. On the contrary, specimens with diameters of 30 and 110 mm had a significant axial contraction and thick white fracture. The hardness of the 110 mm ingots was 341 H_B. Its carbon content decreased to only 2.45%, i.e., by 56% in comparison with calculation.

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Figure 3 shows graphite grains, separated by dissolving magnesium cast iron specimens in 20% persulfate of ammonia.

The apparent decrease of carbon in magnesium cast iron with a pearlitic-ferritic structure may be due to the partial loss of graphite in taking shavings for chemical analysis or incomplete determination of carbon using the usual methods of analysis. A change of carbon content in magnesium cast iron is of great practical significane in establishing technical casting conditions.

[Appended figures and tables follow:]

Figure 1. Structure of Magnesium Cast Iron, Diluted With Grey Cast Iron to 30% (after annealing). a -- smelt 247-2, specimen ⌀ 30 mm x 100; b -- smelt 247-2, specimen ⌀ 50 mm x 100; c -- smelt 247-2, specimen ⌀ 70 mm x 100

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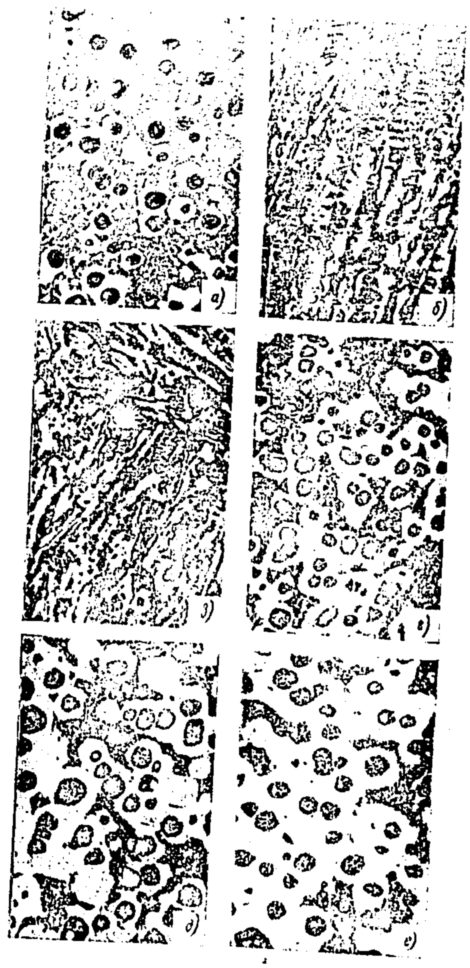

Figure 2. Structure of Magnesium Cast Iron. a -- smelt 314-2, specimen ∅ 30 mm x 100; b -- smelt 314-1, specimen ∅30 mm x 100; c -- smelt 314-3, specimen ∅30 mm x 100; d -- smelt 314-4, specimen ∅30 mm x 100; e -- smelt 314-4, specimen ∅50 mm x 100; f -- smelt 314-4, specimen ∅ 70 mm x 100

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Figure 3. Graphite Grains, Separated From Magnesium Cast Iron

Table 1

Smelt No	Chemical Composition: C	Si	Mn	S	P	Mg	Resistance to Bending: σ_b (kg/mm^2)	f (mm)	Resistance to Breaking: σ_b (kg/mm^2)	δ (%)
247	3.77	2.77	0.64	0.01	0.128	--	Initial cast iron			
247-1	--	3.34	0.81	0.003	0.123	0.04	107-119*	5-7	--	--
247-2	--	3.14	0.75	0.003	0.123	0.03	96.1*	7-0	--	--
250-2	--	--	--	--	--	--	87.8	9-11	--	--
271	3.75	2.20	0.6	0.027	--	--	Initial cast iron			
271-1	3.63	2.66	0.71	0.007	--	0.05	82-89*	27-40	--	--
272-2	3.65	2.33	0.68	0.006	--	0.025	65-87*	8-13	52.4	1.0-1.5
314	3.55	2.40	0.58	0.029	0.122	--	Initial cast iron			
314-1	3.50	2.40	0.60	0.013	--	0.07	--	--	--	--
314-2	3.50	2.61	0.65	0.018	--	0.06	100.5	7.5	--	--
314-3	3.55	2.49	0.58	0.009	--	0.03	85-90*	10-11	--	--
314-4	3.30	2.65	0.61	0.005	--	0.03	104-106	14	--	--

*Specimens were tested after annealing.

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Table 2

Smelt No	Liquid Cast Iron, (kg)	Additions (%) Metallic Magnesium	Magnesium Alloy*	[illegible] Iron (%)	Additions of 75% Ferrosilicon (%)	Appearance of Fracture	Microstructure
247	Initial cast iron		--	--	--	Grey	Lamellar graphite pearlite + ferrite 20-25%
247-1	25	--	1.4	--	--	White	Spheroidal graphite + pearlite + ledeburite 60% (H_B = 321)
247-2	19	--	1.4	30	--	White	Spheroidal graphite + pearlite + ledeburite (H_B = 321)
250	Initial cast iron		--	--	--	Grey	Lamellar graphite + pearlite + ferrite 20%
250-1	20	0.5	--	--	--	White	Spheroidal graphite + pearlite + ledeburite 60%
250-2	15	0.5	--	50	0.3	Light grey, characteristic of magnesium cast iron	Spheroidal graphite 20%, remaining lamellar or psuedo lamellar (H_B = 207)

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271	Initial cast iron		--	--	--	Grey	--
271-1	25	--	1.0	--	--	White	Spheroidal graphite + pearlite + ledeburite (H_B = 444)
271-2	19	--	1.0	45	--	White with dark spots in the center of the specimen	Spheroidal graphite 25-30%; the remaining lamellar or pseudo lamellar + pearlite + ledeburite (H_B = 342)
314	Initial cast iron		--	--	--	Grey	Lamellar graphite + pearlite + ferrite 20%
314-1	25	0.7	--	--	--	White	Spheroidal graphite + pearlite + ledeburite 60% (H_B = 444)
314-2	4	0.7	--	--	0.6	Light grey	Spheroidal graphite + pearlite + ferrite -25% (H_B = 229)
314-3	19	0.7	--	30	--	White	Spheroidal graphite + pearlite + ledeburite 60% (H_B = 477)
314-4	21	0.7	--	30	0.55	Light grey	Spheroidal graphite + pearlite + ferrite 50% (H_B = 217)

*The composition of the alloy is 24% magnesium, 45% silicon, 15% manganese, and the remainder, iron.

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Table 3

Smelt No	Chemical Composition* GA" (State Motor Vehicle Plant imeni Molotov)			NAMI (State Scientific-Research Motor Vehicle Institute)			Addition of Ferrosilicon	Sand Cast (s) and Chill Cast (k)	Appearance of Fracture
	C	Si	Mg	C	Si	Mg			
314-0	3.55	2.40	0	3.65/3.60	2.27	0		Initial cast iron	
314-1	3.50	2.40	0.07	3.60/3.53	2.16	0.081	--	s	White
314-2	3.30	2.61	0.06	3.2/3.0	2.54	0.085	x	s	Light grey
314-3	3.55	2.40	0.03	3.55/3.45	2.18	0.04	--	s	White
314-4	3.30	2.65	0.03	3.16/3.02	2.58	0.03	x	s	Light grey
191-0	3.50	2.20	0	--	--	--		Initial cast iron	
191-1	3.30	2.75	0.04	--	--	--	x	s	Light grey
191-1	3.45	2.75	0.04	--	--	--	x	k	White
207-0	3.60	2.62	0	--	--	--		Initial cast iron	
207-1	3.30	3.08	0.04	--	--	--	x	s	Light grey
207-1	3.50	3.08	0.04	--	--	--	x	k	White
207-1	3.30	3.08	0.04	--	--	--	x	k	Annealed
201-0	3.70	2.39	0	--	--	--		Initial cast iron	

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201-1	3.53	3.01	0.04	--	--	--	x	s	Grey**
201-1	3.63	2.88	0	--	--	--	--	s	Grey***

* For comparison the same specimens were submitted to chemical analysis in GAZ and in NAMI

** Annealed specimen

*** Specimen cast from the foregoing resmelted specimen

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